Investigation of ferroelectric behavior of $Bi(Fe,Sc)O_3$ multiferroics using piezoresponse force microscopy

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Bismuth ferrite (BFO) has attracted an immense attention as a rare room-temperature single-phase multiferroics. The magnetic and ferroelectric structure of BFO can be tuned by cationic substitutions, however the single phase existence range is limited. It can be extended using the high-pressure synthesis method. In particular, this method was applied to sinter $BiFe_{1-x}Sc_xO_3$ ceramics [1,2]. The material appears in different polymorphs. The phase obtained by quenching under pressure is antipolar. However, thermal cycling at normal pressure irreversibly turns this phase into a polar one. The resulting modification is a rare example of coexistence of canted ferroelectric and ferromagnetic states.

Relatively large conductivity and complications to sinter dense ceramics make difficult study and even verification of macroscopic ferroelectric properties. These obstacles can be overcome implementing piezoresponse force microscopy (PFM) addressing ferroelectric behavior at the local scale. The post-annealed $Bi(Fe_{0.5}Sc_{0.5})O_3$ ceramics show a strong PFM signal and possess a well-developed domain pattern typical of a ferroelectric state. The quenched ceramics, however, demonstrate no piezoresponse that is in line with its antiferroelectric state. We found that this state can be transferred to a ferroelectric one by application of a strong enough electric field. In $Bi(Fe_{0.6}Sc_{0.4})O_3$ ceramics a coexistence of ferroelectric and antiferroelectric grains was observed. In latter a ferroelectric state could be induced by electric poling. The temporal and temperature stability of the induced states was studied. Mechanisms of antiferroelectric-ferroelectric transformation are discussed.

This work was supported by the TUMOCS project that has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 645660.

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